TRAINERS' MANUAL ACCOMPANYING "GEOGRAPHIC INFORMATION SYSTEM: PRACTICAL TRAINING MANUAL FOR AGRICULTURAL RESEARCH CENTERS"

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The pedagogical approach of the training

This is the trainer's manual for the GIS training for agricultural research centers, explaining to potential organizer of a training the principle upon which the training has been built up. In addition this training comes with a participant's manual and a CD rom with necessary geo-data.

Objective of the training

The objective of this GIS training, relevant for agricultural research centers, is not only to teach basic manipulation of GIS, but also to enable the participant to apply her/his knowledge in a different context. It is based on the emerging pedagogical concept of outcome based adult education. It focuses on the capacity of a participant to select and perform correct spatial manipulation in Arc GIS. To reach the objective the training uses practical exercises that lead the participant through different spatial problems and discusses the choice of manipulation and implementation in ArcGIS. As such participants can "learn by doing". They acquire not only the knowledge about GIS manipulation but also the capacity to choose the right manipulation in a different context. Moreover, the course is built in such a way that each participant can learn at her/his own pace and build in topics relevant to her/his own interest.

Structure of the training

Each chapter in the participants' manual covers one GIS topic. The first part of the chapter explains basic GIS principles. This part is meant be presented in a traditional classroom setting. The second part shows how to implement the concepts discussed within ArcGIS. The different manipulations in ArcGIS, and their various options are discussed in detail. The third part consists on hands-on session, where participants will explore the various manipulations on their own through a series of exercises. Both part two and three are meant to be discovered by participants on their own, with support of trainers when clarifications are needed.

The exercises are developed is such a way that participants first discover and compare the different manipulations in ArcGIS and then learn when to choose which manipulation with the right options. Also, some questions check whether the participant has acquired the basic GIS knowledge.

Generally, exercises build on knowledge and manipulations that should have been acquired in a precedent chapter. This allows trainers to cross check whether participants have truly reached the learning objective of the precedent chapter and can if needed come back to the points that poses problem. Also, the last day of the training foresees that participants bring in their own topics, allowing to check if participants can apply the acquired knowledge to a different context.

Factor for a successful training

The success of the training depends on several factors: i. the relevance of the exercises to the participants ii. the amount of trainers that are available for supporting the participants, iii. the option to learn at one own pace, iv. the quality of the exercise discussions.

Firstly, the topic covered by this training has been shaped to the particular needs of local researcher in the agricultural centers. Indeed, nowadays the amount of digitized geodata available in Ethiopia is relatively low, topographic maps for example only available as hard copies. Therefore training includes topics that go beyond basic GIS manipulation, like geo-referencing and data editing as well as the use of GPS. Additionally, all exercises are taken from a broader land use planning and agricultural background, using available Ethiopian geo-data.

Secondly, participants are asked to discover GIS manipulation on their own. For a successful training, one trainer for 4-5 participants is needed in order to have enough time for personalized answers and adjust exercises to individual points of interests. In order to insure the quality of the support, at least one of the trainers should be a GIS specialist with advanced knowledge. This person can support the other trainers when needed.

Thirdly, in order to give sufficient time to participants having more difficulties to learn, without getting the fast learners annoyed, a series of more advanced exercises are presented in the manual. Participants have the tendency to rush through in order to solve them all, resulting in the feeling that the training has too much content. It is therefore the task of the trainers to remind the participant that exercises marked with * should only be solved by participants who have preliminary knowledge of GIS and to make sure that each participant truly can learn at her/his own pace.

Fourthly, after every break, exercises and concept discovered in the preceding session need to be discussed in plenary. The objective of these discussions is to ensure that all the participants have fully understood the challenges of the exercises. Participants that did not reach the objective of a given exercise need to be identified and should get personalized explanations.

How to use this manual

Quality of the training depends on the capacity of the trainers to insure that all the concepts and the challenges raised by an exercise have been well understood. The objective of this trainers' manual is to provide the learning outcomes that should be reached after each exercise. It can be seen as a check list of major issues to be addressed for each exercise.

> *1.1 Exercises are numbered and presented in a text box is in the participant's manual. The trainer's manual refers to these exercises.*

As such, the trainer's manual provides a base for the plenary discussions that take place at the end of each chapter. It is assumed that the trainers have good knowledge about GIS. Rather than focusing on the steps needed to solve an exercise, this manual provides the check list to help the trainer to summarize each session. It provides the knowledge and capabilities that participants should have acquired through the exercise that goes beyond the explanations given in the participants' manual. One way of leading the discussion is to ask participants about their learning process, and use the check list to make sure that all the points have been addressed.

The structure of each exercise discussion is as follows: first the learning outcome of each exercise is stated, and then specific answers to the questions are given, followed by any additional comment.

Exercise 2-1

After this exercise participants are able :

- To use ArcCatalog for exploring data
- To differentiate between spatial and non spatial data types
- To understand the difference between vector and raster dataset
    - For vector data, a line of record in the attribute table represents a feature
    - For raster data, a line in the attribute table represents a cell value and number of cell with this value
- To be aware of the importance of metadata
    - Able to edit metadata with the most relevant information

Specific answers to the questions

1. Click on the first file “woreda”. What type of data is it? (vector or grid based?)
   Can you preview the data? What does the metadata tell you? How many attribute does this map have? Can you create a thumbnail?
   Woreda is a shapefile made of polygons. It presents the political boundaries of Ethiopia.
2. Do the same with the “towns_amhara” file. What type of data is it? What is the difference between this and the previous dataset?
   This is a shapefile made of points.
   Look at the file “dem_ethiopia”. What does this file show? What is the difference with the two previous files you looked at and this one?
   This is the elevation map of Ethiopia. It is in raster form. For raster the attribute table represents a cell value whereas for shape file each line represents a feature.
3. Look at the files “RR”, “Tmax”, “Tmin”. What type of file are they? What are the spatial characteristics of these files?
   These are text file. The textfile contains coordinates which will allow to map the point, but the file as such cannot be mapped (without further manipulations)
4. Choose one file, for which you indicate in the metadata that the file is used for training purposes.
5. What are the reasons for creating and adjusting metadata?
   Metadata gives information about what the type of data, year and method of collection, restriction in use and authorship. Metadata is crucial when data is shared.

Exercise 3-1

After this exercises participants are able:

- To launch ArcMap and load data
- To switch on and off layers
- To rearrange layers in the map

- Identify the source file of the data mapped

Participant feel at ease with the ArcMap interface.

Specific answers to the questions

1. Launch ArcMap
2. Load the “woreda” shapefile. What do you see? Can you see Lake Tana?
   It shows the woredas of Ethiopia as polygone
3. Load the “towns_amhara” shapefile. Can you see the map? What does it show?
   It shows the towns of Ethiopia as points.
4. Rearrange the order of the layers. Which is the smartest order to organize your layers?
   The smartest way is to put points at the top, followed by lines, followed by polygons. In this way one makes sure that no features “ disappear” behind another one.
5. Switch off (take away) the towns from your map
6. Can you identify the source directory of the layers?
7. Guess which point is the town of Bahir Dar

Exercise 3-2

After this exercises participants are able :

- To change symbology of the maps
- To make the difference between category and continuous data
- To create own categories for category data
- To understand the importance of classification for continuous data
- To make relevant graphs

Answers to specific questions

1. Give each woreda a different color
2. Give all of the woredas within a single zone the same color
3. Color Tana lake in blue. What challenge are you facing?
   Tana lake is not part of the map, it is a “whole” not a polygone. For this reason, it is not possible to change the color of the lake. The only option would be to make the background color blue.
4. Make all the woredas from Amhara and from Oromia the same color
   Show participants how to make “grouped values” in category data.
5. Make a woreda map that shows the woreda where you come from in one color and all the other in another color. (hint : use “add values”)
   Show participants how to add a unique value as category.
6. Make a woreda map that shows population of each woreda. (hint : use quantities instead of categories). What is the difference with the previous map?

Continuous data needs to be classified. There are different approaches to classify. The classification approach has an influence on the map. For example a Jenks classification tend to make maps with bigger diversity than equal interval. Indeed the latter might smooth data and "loose the patterns"

7. Load the "town_amhara" shapefile and make a graph for each town showing population. Which graph makes sense? (hint : use charts)
   For this specific question it makes sense to make a bar graph, the town with the biggest bar has the highest population. But one could also make a pie graph showing rural and urban population.

Exercise 3-3

After this exercises participants are able:

- To understand how GIS store data and projects

Answers to specific questions:

1. Save your work in a project, so that you can continue working with it in the next days.
2. Change the name of one of your layer, by clicking once on the name. Did the name of your data file change? (Hint : use propreties → source)
   Data does not change name when the name of the layer is changed in the project.
3. Use window explorer and find the woreda shapefile. How many files are needed to map a shapefile?
   There are 7 files. The most important ones are : the database (dbf) that can be open with excel, the projection (prj), the metadata (xml), the shapefile (shp).
4. Copy all the files related to the woreda shapefile. Change the name of the.dbf file. Try to load the "woreda copy" file. Does it work? Delete the copied file.
   If only one the files is changed or deleted the map cannot be opened in ArcMap anymore.
5. Go to ArcCatalog, copy the woreda file, name it woredabis. Check what happened with windows explorer.
   Changes made in ArcCatalog are applied to all the 7 files.
6. What do you learn from the previous procedures?
   All changes done on spatial data should always be done in ArcCatalog.

Exercise 4-1

After this exercises participants are able:

- To understand how vector data is linked to a feature
- To perform sorting manipulations and statistics in the attribute table
- To select feature from the attribute table and with the selection tool
- Export selected data

Answers to specific questions

1. Open the attribute table for the " town_amhara" shapefile
2. Which are the 3 biggest towns in terms of population? (hint use the "sort" option)
   There are different population variable in the file, so it depends on the field chosen.
3. Select these 3 towns in the attribute table
4. Which woreda are they in (hint use "woreda" shapefile and activate map tips)?
5. Freeze the column '"woredaname". Move across the attribute table. What is the purpose of freezing column?
   It allows consulting the whole database and always seeing the woreda name.
6. Find the town of Bahir Dar by using the identify tool.
7. Select all of the woredas around Lake Tana.
8. How many woredas have you selected? (hint use "show selected" in the attribute table)
9. Export these woredas into a new layer and name it "tanaworeda"
10. * What is the total area of the selected woredas? (hint use "Statistics")

Exercise 4-2

After this exercise participants are able to

- Create a new field
- To calculate record values for a new field
- Make the difference between field calculator and field geometry

Answers to specific questions

1. Load the woreda shapefile. Create a new field that indicates population density (density is calculated as population/area).
2. Calculate the perimeter of each woreda.
3. What is the coordinate system of your data? Why does it matter?
   The data needs to be projected. Projections come in a latter chapter, but it is important to raise the awareness at this stage that depending on the coordinate system chosen one might not be able to compute geometry.
4. *Calculate the area of each woreda. The woreda file already contains a field called area. Do you find the same values?
5. *What is the area of Ethiopia? (hint: use the statistics option). If you have internet access compare it with the official statistics.
   One can sum up the area of each woreda to get the area of Ethiopia by using the statistics option (sum).
6. *What is the perimeter of Ethiopia?
   However, the statistics cannot be used for computing the perimeter of Ethiopia. One might need to dissolve the woreda. This question aims at making people reflect about what they are doing.

GIS is not only about manipulations. It is about making the manipulations needed to get the answers to a specific question.

Exercise 4-3

After this exercise participants are able:

- To perform a relate and a join
- To understand the application of join and relate
- To understand the need of validation of maps

Answer to specific questions

1. Open the “atlas” shapefile. What type of data does it contain?
   It contains socio-economic data from the rural economy atlas (IFPRI)
2. Which field can be used for join or relate? What does this field characterize?
   You need to use the woredaid field, which is the same in both files
3. Perform a relate with the woreda map then open the attribute table. What do you see?
   The two tables are related by the attribute table did not change.
4. Deactivate the relate
5. Make a join? Open the attribute table? What is the difference with the relate?
   The join links the two table, which when exported provides a file with both dataset. Note that the Atlas file only contains some woredas. This implies that many woredas will not have a value if the option keep all record is used, or many woredas will be drop if only matching woredas are kept.
6. Make a map of different socio-economic variables? Choose a woreda you know, does the data makes sense to you?
   This is data from 2005 based on a sample survey. It is likely that this data does not represent the today’s situation. Participants should learn here, that map always should be taken with cautious and be validated.

Exercise 5-1

After this exercise participants are able:

- To create new geographical dataset using selections by attribute
- To query a database wish simple SQL queries

Answers to specific questions:

1. Select all towns which have a population greater than 10,000 inhabitants in the “town_amhara” shapefile. Can you select these using 2 different methods?
   One method is the manual, sort the attribute table on population and then select the one with more than 10 000 inhabitants.
   The second method is a selection by attribute from the selection menu.

2. Load the “basin” shapefile. Select the Tana basin using the SQL query builder and save it into your folder.
   This question aims at teaching to use SQL with strings : by using the get all values option.
3. Select all town bigger than 5’000 inhabitant in the Siemin zone
   This question aims at making the difference between AND and OR. The inhabitant conditions needs to be true AND the Siemin zones. Because there are different Siemen zones, OR needs to use to capture them all.

Exercise 5-2

After this exercise participants are able:

- to create new geographical dataset using selections by location
- to understand the concept of buffers

Answers to the specific questions

1. Load the road shapefile and select all woredas which are crossed by a gravel road.
   For this exercise one needs to first select gravel road (selection by attribute) then a selection by location. Use the “intersect” command.
2. Load the town_amhara shapefile and select all towns that are within 2km from a road. How many towns did you select?
   This exercise aims at making a selection with a buffer. Use the command “ near to”
3. What is a buffer? Do you have an example in the agricultural context for which buffers can be useful?
   A **buffer** is a zone around a map feature measured in units of distance or time. A buffer is useful for proximity analysis. A buffer around a farm stead for example, can be a proxy for the fields belonging to the farm.

Exercise 6-1

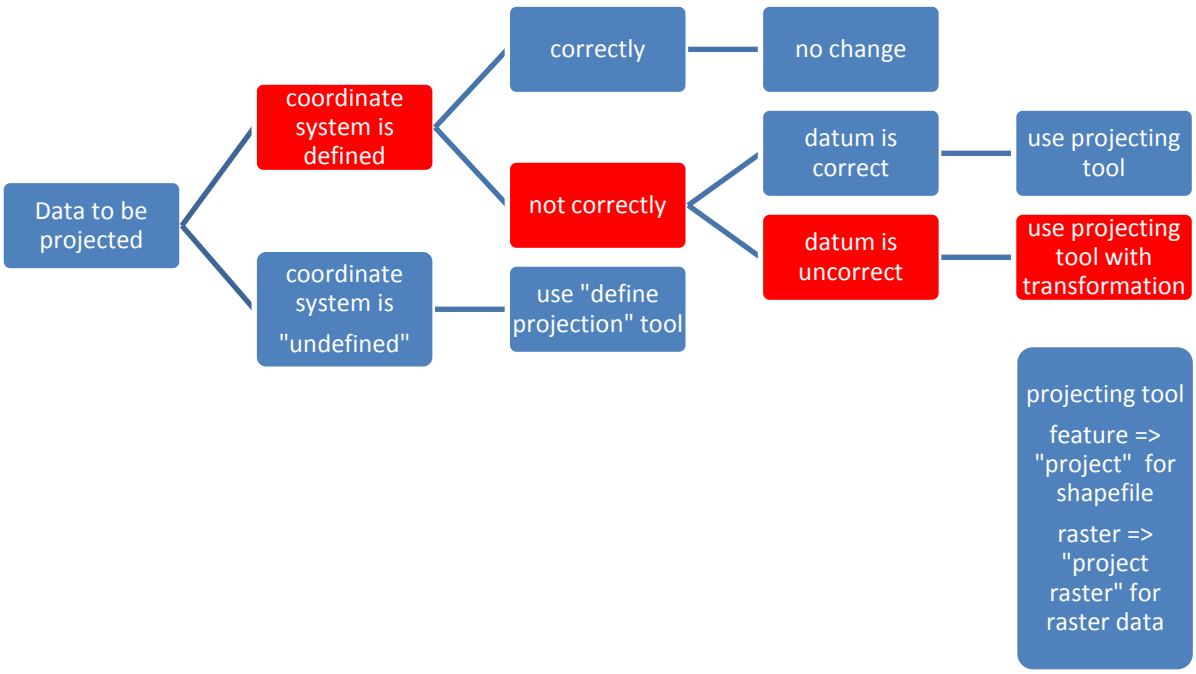
After this exercise participants are able:

- To understand the concept of datum, geographic coordinate, projection and transformation
- To perform correct projection and transformation change change
- To understand implications of wrong projections

Answers to the specific questions

1. Start a new project. Load the woreda2 shapefile and woreda shapefile.
2. What happens? What does ArcGIS tell you?
   A warning indicating that there is some issues with projections is appearing.
3. In what coordinate system is the woreda shapefile? (hint go to “Properties” and “Source”)
   It is WSG84 projected UTM

4. What is the coordinate system of the woreda2 shapefile?
   It is in Adindan
5. Zoom in as much as possible, do the boarder match? What happens if you use the wrong coordinate system?
   The boarders do not match, because the datum is not the same for both maps.
6. Transform the projection for Woreda2 into the same coordinate system as the town_amahra shapefile. Do the borders match?



   One needs to change datum with the transformation Adindan to WGS84 transformation number 4.
7. Can you explain the difference between a projected and unprotected map?
   Unprojected maps are in degrees and therefore cannot be used to measure in terms of meters. When a map is projected, then

Exercise 6-2

After this exercise participants are able:

- To georeference based on control points

Answers to the specific questions

1. In a new project load the scanned topographic map “woreda.tiff”. What do you have to do before loading the data?
   Look at the image and rotate it.
2. How does ArcMap read the coordinate system of the data? Check the map units. What is the coordinate system of the data?
   There is no coordinated system defined
3. With the georeferencing tool, georeference the topographic map by choosing control points.

Exercise 6-3

After this exercise participants are able:

- To georeference scanned image with help of existing shapefile

Answers to specific questions

1. In a new project load the file “Ethiopia.jpg” and the woreda file (make sure that you use woreda file and not woreda2)
2. Do the two files match? If not, why not?
   The image has no coordinate system
3. How does ArcMap read the coordinate system? Do you observe any difference from the previous exercise? If so what? What is the coordinate system of each of the files?
   Woreda is in WGS84 projected whereas the image has no defined coordinate sytem
4. *With the georeferencing tool, georeference the image by choosing 2 control points.*
5. Add some more 2 control points. How does it change the georeferencing. How many points do you need for geo-referencing the Ethiopia image?
   Depends on the person about 4-8 points

Exercise 7-1

After this exercise participants are able:

- to good looking maps for publication
- To understand criteria that make maps readable

Answers to specific questions

1. Display the Tana woredas (tanaworeda shapefile created in a previous exercise) giving a different color to each woreda. Add another data frame that shows Ethiopia and highlights the selected woredas.
2. Add a North arrow, a legend and a scale bar

3. Label the woredas and make sure that each woreda is labeled in a clear and distinct way.
4. What are the criterias to make your map readable?
   Labels, title and legend need to be big enough
   Use colors that make sense (blue for water, green for nature, red for urban)
5. Link the two data frames so that when you move one map, the other also adjusts automatically? Can you create a map that shows the extent of one data frame within another data frame (Hint look in frame properties – extent indicator)

Ask participants to export their map. Project and discuss their maps in plenary.

Exercise 8-1

After this exercise participants are able:

- To perform and understand a clip operation

Exercise 0-2

After this exercise participants are able:

- To perform and understand a dissolve operation

Exercise 8-3

After this exercise participants are able:

- To perform and understand a union

Answers to specific questions :

1. Make a union with laketana shapefile and woreda shapefile.
2. Open the attribute table of union. What can you see?
   Lake Tana is now part of the woreda shapefile
3. Can you color Lake Tana in blue? Compare with exercise 3-2
   Because Lake Tana has its own shape it can be colored in blue.

Exercise 8-4

After this exercise participants are able:

- To perform and understand an intercept
- To understand the difference between intercept and union

Answers to specific questions :

1. Intercept the Lake Tana basin with the Tana woredas.
2. Open the attribute table of result. What can you see?
   There are more attribute line, as the interception creates more shapes

3. Compare the results from the union and intercept operations. What is the difference between the two?
   Union unites 2 shapefiles and interscept overlays them.

Exercise 8-5

After this exercise participants are able:

- To recognize and understand characteristics of rasters.
- To map raster data
- To understand the concept of resolutions and cell size

Answers to specific questions:

1. Load the elevation raster layer “dem_eth”. What type of raster is it?
   It is a floating raster
2. What is the coordinate system?
   It is in WGS84 projected
3. What is cell size and how many columns and rows does the image have?
   Cell size 1 km and 1651, 1273
4. What are the minimum and maximum values?
   -152 and 4378
5. Choose a Color ramp of brown to white symbolizing elevation.
6. Which part of the Ethiopia has higher elevation values?
   The highlands
7. What is the grid size? What are the implications of the grid size on the analysis performed with the digital elevation maps?
   The bigger the cell size the lower the resolution, the more “ errors are made” and the less precise the data is.

Exercise 8-6

After this exercise participants are able:

- To transform a shapefile into a raster

Exercise 8-7

After this exercise participants are able:

- Reclassify raster value

Exercise 8-8

After this exercise participants are able:

- To clip a raster

Exercise 8-9

After this exercise participants are able:

- To perform surface and hydrology computation on elevation maps

Exercise 8-10

After this exercise participants are able:

- To use raster calculator
- To perform a simple suitability analysis
- To be aware of different raster aggregation techniques

Answers to specific questions :

1. You have created a potatoes suitability map in terms of elevation, slope and soil. Combine the three into a potatoes suitability map (hint use raster calculator). What are the mathematical rules that you could use for the aggregation? Which one would you choose?
   The simplest approach is to aggregate the different rasters. The simplest one is the multiplication. It implies that all the criteria are "killer", meaning all conditions need to be true for indicating a suitable area. Another option could be the aggregation of different raster. The aggregated raster can then be normalized (getting values between 0 and 1)
2. Perform different aggregation techniques and compare the outcome.
3. What is your opinion about the suitability map that you have created? Are there other variable which should be included to determine the suitability for potatoes?
   There could be many other variables to be taken into account, such as rainfall.
4. Create your own model for the suitability of potatoes, search for any data you are missing (on the CD, or in exercise folder, or on the internet), and perform your own suitability analysis.

Exercise 9-2

After this exercise participants are able:

- To understand the challenges linked to interpolation
- To perform an inverse distance weighting interpolation
- To understand how to introduce new data into a suitability analysis

Answers to specific questions:

1. Load the shapefile you have made from the "RR.txt" file in a previous exercise. Interpolate this data by using inverse distance weighting.
2. What does the new map tell you?
   It gives a full coverage rainfall map.
3. How would you use this map for a suitability analysis? Perform this step and add the result to the suitability analysis run in the raster data chapter.

Potatoes are suitable on mean annual rainfall between 700 to 2600mm. One can reclassify the interpolated map and use it as a new raster in the suitability analysis as performed in exercise 8-10.

Exercise 9-1

After this exercise participants are able:

- To create XY events from coordinates
- To understand how to introduce new data into a suitability analysis

Answers to specific questions:

1. In a new project, load the RR.txt file.
2. Project these points and save them as shapefile.
   Use the XY event
3. What is the correct coordinate system for this shapefile
   Use WGS84 unprojected, because the data in longitude latitude.
4. What does type of information is given by the RR shapefile? Make an informative map with this data.
   Make a map that shows the intensity of rainfall at each meteorological station.

Exercise 9-3

After this exercise participants are able:

- To use a GPS correctly
- To set GPS settings correctly
- To collect waypoints and tracks
- To make use of the area measurement tool
- To download and project the data in ArcGIS

Answers to specific answers

1. Download the track and waypoints from your field trip.
   Make sure that the GPS is on connected mode
2. Map the points and the tracks.
3. What are the coordinates of the points of interests that you have visited?
   Check the format of the coordinate.
4. What is the distance from starting point of the field trip to the points of interests?
   To do this data needs to be projected first.
5. What is the area of one of the points of interests?
6. Add metadata to the data you have collected during field trip.
   Remind here to always make metadata.

Exercise 10-1

After this exercise participants are able:

- To use a personal geodatabase
- To recognize its content

Answers to specific questions :

1. Explore the personal geodatabase 'ARARI'
2. How many feature classes are inside the database?

   2
3. Preview the feature class 'woredas'
4. What is the geometry type of this feature class?

   polygone
5. How many records exist in the feature class?

   129

Exercise 10-1

After this exercise participants are able:

- To create and use a personal geodatabase
- To understand the use personal geo-database

Answers to specific questions

1. Create a new geodatabase
2. Create a new feature class with' point' geometry type
3. Set the spatial reference of the feature class to UTM Zone 37
4. What is the advantage of working with a personal geodatabase?

   It allows to manage data in an efficient and ordered way.

Exercise 10-1

After this exercise participants are able:

- Create and edit point shapefiles
- To digitize images

Exercise 10-1

After this exercise participants are able:

- Create and edit line and polygone shapefiles
- To digitize images and topographic maps